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(54) Title: MACHINING TOOL OPERATOR TRAINING SYSTEM

(57) Abstract

The present invention is a an interactive multimedia training system which incorporates text, audio, and video graphics animation and other tools to teach an operator to use a machining or other tool. The training system includes a computer workstation to allow inputs from an operator, computer memory, and a training computer program operating on the computer and having a graphical user interface for interfacing the operator with the workstation and interactively training the operator to operate and perform tasks on the machine tool. The operator can provide inputs to the training system by various input devices such as a keyboard, cursor or mouse. The training system additionally includes interface software operating on the computer for controlling the machine tool and sharing access to and exchange data with the computer memory and a remote station linked to the computer memory for allowing an instructor to monitor and supervise the operator in real time.

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MACHINING TOOL OPERATOR TRAINING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates to interactive, computer-based training systems. More particularly, this invention relates to a multi-media application software operating on a computer comprised of text, audio, video and computer graphics animation for teaching an operator how to use a device, such as a machining or other tool in an environment outside the computer.

2. Related Art.

The devices available to train a person, such as a tool operator, have in the past incorporated various options. Primarily, however, most operator training has been conducted by theoretical training in a classroom setting, or practical training whereby the operator is trained by using the actual tool in question to manufacture the desired work piece.

Both theoretical and practical training of the type cited above have serious disadvantages. Theoretical training, although providing an overview of the steps and concepts employed in the tooling operation, does little to provide the operator with any manual skill, such as dexterity or steadiness of hand, which may be required in the tooling operation. Many years of actual physical practice are often necessary to develop the skill and knowledge necessary to machine a part. This is particularly true if the machined part or process used to machine it is complex. Additionally, theoretical training does little to build the confidence of an operator in being able to manufacture the work piece on their own. Another drawback with theoretical training in a classroom setting is that it may be ineffective for the student to listen to lectures and read a book without being able to

apply what is learned or to assess their knowledge during the course of such training.

Practical, hands on training, on the other hand, allows an operator to develop the skill and understanding necessary to effectively operate the tool to machine a work piece. However, a draw back with standard practical training is that although it provides the operator with experience to build the part or conduct the process in question, any mistakes made in this process may be costly. Valuable time and material is then required to correct such mistakes.

Hence, a training tool is needed that allows the operator to gain both theoretical and practical knowledge and skill while avoiding costly mistakes. This training tool should maintain the interest of the student and allow them to self-assess their knowledge and skill during the progression of training. It should provide for many techniques and aids to allow the student to most effectively gain and retain the information provided.

SUMMARY OF THE INVENTION

To overcome the limitations in the prior art described above, and to overcome other limitations that will become apparent upon reading and understanding the present specification, the present invention is an interactive multi-media training system which incorporates text, audio, and video graphics animation and other tools to teach a user (in the description that follows, the term user is used interchangeably with the term operator) to use a device in an outside environment, such as a machining or other tool without the drawbacks of traditional practical training.

The training system includes a computer workstation to allow inputs from a user, such as a machine operator trainee, computer memory, and a training computer program operating on the computer and having a graphical user interface for interfacing the operator with the

workstation and interactively training the operator to operate and perform tasks on the machine tool. The operator can provide inputs to the training system by various input devices such as a keyboard, cursor or mouse.

In addition, the training system can include interface software operating on the computer for controlling the machine tool. The interface software can share access to and exchange of data with the computer memory. Also, the training system can further include a remote station linked to the computer memory of the interactive computer. The remote station can have an instructor for monitoring and supervising the operator in real time. Moreover, the remote station can share access to and exchange data with the computer memory.

The graphical user interface includes a Main Menu area which allows the user to select a specific training category, such as a tooling category associated with the actual machining operation of a specific part for that tooling category. Once the Tooling Category for a specific part has been selected, a Tooling Operation Submenu appears on the display which allows the operator to select a Tooling Operation for which he or she desires training. Various functions, such as an example of machining the part, practice for machining the part, simulation of machining the part, a diagram of the part, expert advice on machining the part, a walk through of the machining function and a self-test function, are also included for each tooling operation for each part. These functions are accessible via the graphical user interface.

The training system has many advantages. It serves as a quick reference guide. In addition to the computer-based training mode, the training system may be, but does not have to be, interfaced with an actual tool to allow the user to simulate the function that will be carried out. Additionally, the training system serves as a self

testing device. That is, the training system allows the operator to test themselves on the task to be performed. Also, the training system serves as a quality control vehicle to ensure the operator learns how to manufacture the work piece effectively before actually making one. It gives the user the ability to access different instructional media. This application will increase the operator's mnemonic capacities and will insure the product is built correctly.

The foregoing and still further features and advantages of the present invention as well as a more complete understanding thereof will be made apparent from a study of the following detailed description of the invention with the accompanying drawings and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in which like reference numbers represent corresponding parts throughout:

Figure 1A is an overall block diagram of the present invention.

Figure 1B is a block diagram of the operation of the interface software with the machine tool.

Figure 2 is an overall illustration showing a general flow chart of the training system of the present invention.

Figure 3 provides a more detailed overview chart of the modules accessible from the Main Menu of the present invention.

Figure 4 illustrates the graphical user interface of the Main Menu of the present invention.

Figure 5 illustrates an alternate view of the graphical user interface of the Main Menu of the present invention.

Figure 6 illustrates the graphical user interface of the Tooling Operations Submenu.

Figure 7 illustrates the graphical user interface of the training system once a tooling operation has been selected from the Tooling Operation Submenu.

Figure 8 illustrates the graphical user interface of the training system when the Expert Functional Module has been selected.

Figure 9 illustrates the graphical user interface of the training system when the Simulation Functional Module has been selected.

Figure 10 illustrates the graphical user interface of the training system when the Practice Functional Module has been selected.

Figure 11 illustrates the graphical user interface of the training system when the Diagram Functional Module has been selected.

Figure 12 illustrates the graphical user interface of the training system when the Expert Functional Module has been selected.

Figure 13 illustrates the graphical user interface of the training system when the Walk Thru Functional Module has been selected.

Figure 14 illustrates the graphical user interface of the training system when the Walk Thru Functional Module has been selected.

Figure 15 illustrates the graphical user interface of the training system when the Test Functional Module has been selected.

Figure 16 illustrates the graphical user interface of the training system when the Bookmark Functional Module has been selected.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following description of the preferred embodiments of the present invention, reference is made to the accompanying drawings which are a part hereof, and which is shown by way of illustration specific embodiments in which the invention may be practiced. It

is understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

Overview:

Figure 1A is an overall block diagram of the present invention. The present invention is a training system 2 for providing a user 4, such as an operator, with an interactive computer environment 6 with a memory medium 7 and training software 8 operating on the computer 6. The training software 8 has access to and exchanges data with the memory medium 7. The training system 2 trains the operator 4 to perform specific tasks in an environment 9 outside of the computer 6. For example, the training system 2 can teach the operator 4 to machine a part or workpiece 10 with a machine tool 11 by responding to inputs 12 by the operator 4. The input can be stored in the computer memory 7.

The training system 2 can also have, but does not have to have, interface software 14 interfaced to an actual machine tool 11 of an outside situation or environment 9 for direct response and control of the environment 9. The interface software 14 operates on the computer 6 for controlling the machine tool 11. The interface software 14 can share access to and exchange of data with the memory medium 7.

Also, the training system 2 can further include a remote station 16 linked to the computer memory 7 of the interactive computer 6. The remote station 16 can have an instructor for monitoring and supervising the operator 4 in real time. Moreover, the remote station 16 can share access to and exchange data with the computer memory 7. The remote station 16 can be linked to the computer 6 in any suitable networking manner, such as via an intranet or internet connection.

Figure 1B is a block diagram of the operation of the interface software with the machine tool. The interface

software 14 receives data from the Computer memory 7. This data can include preprogrammed commands and instructions for operating the machine tool 11 and/or history profiles of the operator's input to the training software 8. The interface software 14 also receives instantaneous data from the machine tool 11 indicating the tool's 11 position, location, status, etc. The interface software 14 processes the data from the computer memory 7 and the machine tool 11 and sends suitable commands to the machine tool 11 for operating the machine tool 11 in real time.

The computer 6 of the training system 2 is preferably a workstation, such as a windows-based personal computer or a UNIX computer workstation. The workstation 6 includes a primary display 22 which incorporates a graphical user interface 24 of the training software 8. This graphical user interface 24 varies depending on operator input. The training software 8 is an event driven program. Since the training system is event driven, the graphical user interface 24 constantly calls functions and sends messages to the software 8 to indicate that some event has occurred. This allows the training software 8 to directly respond to data and input from the operator 4. The events can include cursor movement, keystrokes, or mouse movements from the operator 4. Also, the training software 8 includes sensory media 29 associated with actual trainable machine tooling events for interactively training the operator 4.

Referring to Figure 2 along with Figure 1A, Figure 2 is a general flow diagram of the training software 8 operating on the workstation 6. Figure 3 provides a more detailed depiction of the information available from the Main Menu 40. As shown in Figure 2, the training software 8 commences with an Introductory Video 30 and then the Main Menu 40 appears. From the Main Menu 40 various tooling categories TC1 through TCn can be

selected by the operator via a tooling category sub-menu 50. Once a tooling category Tcn has been selected a Tooling Operation Submenu 60 appears. This Tooling Operation Submenu 60 allows the operator to select Tooling Operations TO1 through Ton within the particular tooling category.

The operator can select for which tooling operation he or she would like to be trained. Once a tooling operation has been selected, various functions become available to the operator/user with respect to that particular tooling operation. These can include for instance, an example of a tooling operation 80, practice of a tooling operation 81, simulation of a tooling operation 82, expert advice on a tooling operation 83, diagrams 84 of the machined part and tooling steps, a self-test 86 of a particular tooling function, a walkthrough of a particular tooling operation 85 and other functions 87 suitable to interactively train an operator 4.

The graphical user interface 24 includes screen objects to provide event driven functionality for the training software 8. The objects include menu control buttons, integrated windows or viewer areas and icons that allow the operator 4, such as a machine tool operator, to view and select various items as will be discussed more specifically with respect to the specific graphical user interface displays available within the software.

COMPONENTS

In general, the training system software 8 employs various program components and variables that allow the operator 4 to navigate through the training software 8 and enhance the training utility of the software. These are described more specifically below.

Program Components. The interface can be navigated with and controlled by various functions, such as a Quit function, which allows the user to quit the program; a Pause function which allows the user to pause the program; and a forward/backward function which allows the user to move forward or backward through the program. Additionally, the program has a page forward/page backward function which allows the user to move through different sections of the program. The training software also includes a Notepad function throughout, which allows the user to save notes. There is also a print function which allows the user to print out screens and an index function that allows the user to see, at a glance what is included in the program. These program components used for interface control can be programmed keyboard functions or functional screen buttons.

Subject Variables. The application software employs sensory media 29 to enhance the training experience. They include but are not limited to audio, text/hyper text, video, graphics, animation, simulations, and self-test capability.

The sensory media 29 of the training set includes audio features in the form of a friendly audio narrative incorporated in the training software. The audio can be selectively turned on and off. Additionally, operator selectable text/hyper text is included in the system. Each screen of instructional material can be accompanied by the text and the operator selectable hypertext. The hypertext allows the user to access additional information associated with the hypertext. Also incorporated in the training system is video. Many processes and tasks have a video segment associated with them so that the user/operator can see a realistic rendition of the information sought to be provided. Additionally, Expert Advice is included.

For instance, the training system can include an index of frequently asked questions. The response to the question can be in the form of a video which includes text/hypertext, animation, and line drawings. High level graphics are incorporated in the training system to enable the user to see in static or dynamic fashion, the task at hand. Users are provided with a close up of the graphic. Additionally, animations show, in a more advanced manner, the task at hand. The animations can be selectively replayed. Video, graphical or animated simulations additionally give the user/operator the opportunity to observe a simulation of the task before actually carrying it out. A self-test capability is also incorporated. With the self-test capability, the user is able to test themselves, both in a practical and theoretical manner. The results of such tests can be saved to a data base for building a history of each operator or trainee and/or for later review by an instructor or supervisor.

MAINTENANCE.

Maintenance or operator training can be provided by this training system. For instance, a maintenance training module can provide information on troubleshooting and recommended maintenance activities. The specifics of the present invention will, however, be described in more detail with respect to the operator training available.

OPERATIONS.

As stated previously, the workstation includes a graphical user interface that divides the workstation display into various windows and objects. Example base display screens of the geographical user interface are discussed below.

Introductory Scene. The training system software opens to an Introductory Scene 30 as shown in Figure 2. This display (not shown) is divided approximately in half and shows a Heading Window on the left side of the screen and a Graphical Window on the right which may depict an object to be tooled or other device, such as a plane flying over. The Introductory Scene 30 may be accompanied by audio of appropriate sounds, such as the sound of a plane flying over.

Main Menu. Referring the Figures 2 and 3 along with Figure 4, once the initial Introductory Scene 30 appears it automatically turns into the Main Menu 40 for providing access to various training system functions as shown in Figure 4. This Main Menu 40 includes a Header Window 42 for providing header information, such as the name and version number of the training system or the like; a Text Window 44 for providing a text listing of tool category tasks for which training is available appears; a preferably a help window 43 providing explanatory text to the operator 4 (as shown in Figure 5), and a Graphical Window 46 for providing animated images representing a device that the operator is being trained on, such as a three dimensional graphical image. A Rotation Icon 45 in the Graphical Window 46 allows the user to rotate the image in three dimensions. The operator can accomplish this by selecting the Rotation Icon 45 in the desired direction of rotation with a cursor controlled by a mouse (not shown).

Additionally, there are two smaller, operator-selectable buttons 47, 48 which allow the operator respectively to either quit the training software or enter the training tutorial by pointing and clicking the cursor. From the Main Menu 40, the operator can select a tooling category 50 (of Figures 2 and 3), which can be associated with a section of a part, in the Graphics Window 46 with, for example, a mouse cursor (not shown)

for training on that part. As an example of the sensory media, once the operator selects the part for training in the Graphics Window 46, in computer generated animation, that section of the structure to be tooled breaks off, rotates into an appropriate orientation, removes the skin exposing the substructure and rigs the image into the assembly fixture and reveals an Tooling Operations Submenu 60 containing tooling operations of the tooling categories 50 (of Figures 2 and 3) as shown in Figure 6.

Tooling Operations Submenu. Referring the Figures 2 and 3 along with Figure 6, the Tooling Operations Submenu 60 includes a Header Window 72, a Text window 71, a Graphical Window 74 and a function tool bar with functions as shown in Figure 6. The tool bar may have operator selectable buttons 77, 78 which allow the operator to go back to the previous screen, or to bookmark this particular display, respectively. The user selects one of the tooling operations 70 from the Text Window 71 by pointing and clicking with their cursor on the particular Tooling Operation Submenu item desired in the Text window 71.

Referring the Figures 2 and 3 along with Figure 7, once a Tooling Operation is selected from the Tooling Operation Submenu 60, the graphical user interface is updated to display various Functional Module buttons 80a, 81a, 82a, 83a, 84a, 85a, 86a which are selectable by the operator as shown in Figure 7. These Functional Module buttons represent corresponding functional modules 80, 81, 82, 83, 84, 85, 86, of Figures 2 and 3 respectively. The Text Window 71 is updated with instructional text messages informing the operator for which tooling operation this training section is for and that he should click on one of the Functional Module buttons to learn how to operate the tooling device.

By using the mouse cursor and clicking on the appropriate Functional Module button 80a, 81a, 82a, 83a,

84a, 85a, 86a the user can select from the various Functional Modules 80, 81, 82, 83, 84, 85, 86, of Figures 2 and 3 to access an audio/textural tutorial, an activity simulation, a reference guide, line drawings, video clips of the operation, diagnostics, testing and expert advice on the tooling operation.

Additionally, the operator can perform other functions 87, such as bookmarking this screen with the bookmark button 78 and turn the audio on and off with an audio button 89. Other operator-selectable functional buttons 87 include the Back button 77 which allows the operator to go back to the previous screen. Once the operator selects one of the Functional Module buttons the display for this particular Functional Module appears. These are discussed more fully below.

Functional Modules. Various Functional Modules 80, 81, 82, 83, 84, 85, 86, of Figures 2 and 3 can be selected from the functional module buttons 80a, 81a, 82a, 83a, 84a, 85a, 86a, after a tooling operation 70 has been selected. These are described in detail below.

1. Example Functional Module: If the operator selects the Example Functional Module 80 of Figure 2 by selecting the Example Functional Module button 80a, a video clip appears in the Graphical Window 74 as shown in Figure 8. The video clip is accompanied by audio (if turned on), a narration of the procedure being conducted. This Example Functional Module 80 allows the user to become familiar with the tooling operation being taught. The user can toggle the audio on and off by placing and clicking his cursor on the Audio Functional Module button 89a. The user can exit the Example Functional Module 80 by either selecting (with his cursor) the Back button 88a, which takes him back to the previous screen, or by selecting another Functional Module button.

2. Simulation Functional Module: If the operator selects the Simulation Functional Module 82 of Figure 2 by moving his cursor and clicking on the Simulation Functional Module button 82a, an animation preprogrammed in memory appears in the Graphical Window 74. An exemplary scene from this animation is shown in Figure 9. The animated sequence is preprogrammed to replicate actual steps of the process being trained. The preprogrammed-animation provides an animated sequence of the process with close-ups of the important steps. Additionally, the preprogrammed animation is accompanied by explanatory text in Text Window 71 for providing an explanation of the important features of the process as the animation proceeds, also shown in Figure 9.

The animated sequence is preprogrammed to be operator directed. In other words, the animated sequence is stored in digital memory, allowing the operator to proceed to any point in the sequence. For example, the operator can stop an animated sequence in midstep and repeat it or repeat the entire step after it is completed. This allows the user to proceed through the procedure step by step at the operator's own pace. Audio may also accompany the simulation. The user can toggle the audio on and off by using his cursor and the Audio Functional button. The user can exit the Simulation Functional Module 82 by either selecting (with his cursor) the Back button 88a, which takes him back to the previous screen, or by selecting another Functional Module button.

3. Practice Functional Module. If the operator selects the Practice Functional Module 81 of Figure 2 by selecting the Practice Functional Module button 81a with his mouse cursor and clicking on it, a preprogrammed animation appears in the Graphical Window 74. An exemplary scene from this animation is shown in Figure 10. The operator then is allowed to practice going

through the tooling steps. For example, the operator is provided with an animated sequence of steps and is prompted to respond to preprogrammed questions and instructions on how to proceed. As the operator proceeds through the steps, feedback and instructions are provided in the Text Window 71. If the operator makes a mistake an Error Message Window 78 (as shown in Figure 10) is displayed and can be recorded in digital memory.

In addition, a preprogrammed video or animated sequence associated with the error explaining the proper procedure may appear. The programmed sequence describes to the operator his mistake and explains, with video or animated simulation, the proper procedure. An error and progress file profiling an operator is generated for each operator as he goes through the sequence so an instructor or supervisor can evaluate the operator's progress and provide individualized personal attention if necessary. Also, a counter can be included to track each of the operator's mistakes. If such error and progress profiling is utilized then it is necessary for the operator to log in with an identifying log in name or password. Again, audio may accompany this Module to enhance the learning experience. The user can toggle the audio on and off by placing his cursor on the Audio Functional button. The user can exit the practice Functional Module 81 by either selecting (with his cursor) the Back button 88a, which takes him back to the previous screen, or by selecting another Functional Module button.

4. Diagram Functional Module. If the operator selects the Diagram Functional Module 84 of Figure 2 by selecting the Diagram Functional Module button 84a with his mouse cursor and clicking on it, blue prints and images that support the learning process are shown in the Graphical Window 74 as shown in Figure 11. The operator can use hyperpoints or hyperlink capability to obtain a

close up, more detailed view of the image in the Graphical Window 74. The Text Window 71 includes explanatory text and selectable hypertext which allows the operator to access and be directed to additional information. The user can exit the Diagram Functional Module 84 by either selecting (with his cursor) the Back button 88a, which takes him back to the previous screen, or by selecting another Functional Module button.

5. Expert Functional Module. If the operator selects the Expert Functional Module 83 of Figure 2 by moving his cursor and clicking on the Expert Functional Module button 83a, a video appears in the Graphical Window 74 as shown in Figure 12. This video includes advice from an expert discussing common errors in the tooling operation selected and how the user of the training system can avoid them. The user can toggle the video audio on and off by placing his cursor on the Audio Functional button 89a. The user can exit the Expert Functional Module 83 by either selecting (with his cursor) the Back button 88, which takes him back to the previous screen, or by selecting another Functional Module button.

6. Walk Thru Functional Module. If the operator selects the Walk Thru Functional Module 85 of Figure 2 by moving his cursor and clicking on the Walk Thru Functional Module button 85a, the Textual Window 71 is updated to provide buttons wherein other steps of the machining process can be selected for further textual information and additional images are shown in the Graphical Window 74 as shown in Figures 13 and 14. The operator is walked through the sequence of operating steps by textual information provided in the Text Window 71 and a preprogrammed animation that is provided in the Graphical Window 74. The operator is allowed to cycle the displays when he has walked through the sequence of

operating steps. Again, audio may accompany this Module to enhance the learning experience. The user can toggle the audio on and off by placing his cursor on the Audio Functional button. The user can exit the Walk Thru Functional Module 85 by either selecting (with his cursor) the Back button 88a, which takes him back to the previous screen, or by selecting another Functional Module button.

7. Test Functional Module. If the operator selects the Test Functional Module 86 of Figure 2 by selecting the Test Functional Module button 86a with his mouse cursor and clicking on it a preprogrammed animation appears in the Graphical Window 74. An exemplary scene from this animation is shown in Figure 15. The user is allowed to test his progress and acquired skill by having a textual and preprogrammed animated test session. The user's skill and number of attempts before passing may be recorded on the computer in a data base, or possibly on a network server if the training software runs on a network, for immediate review by a superior watching from another site. Additionally, the superior can control the questions in real time during the test if desired. The use of this Test Functional Module 86 allows tracking of performance and trends in performance. The user can exit the Test Functional Module 86 by either selecting (with his cursor) the Back button 88a, which takes him back to the previous screen, or by selecting another Functional Module button.

8. Secondary Functions. The functions of Bookmark, Audio and Back are secondary functions which aid in the effectiveness of the training and allow the operator to navigate through the training software.

If the operator selects the Bookmark function by selecting the Bookmark Functional Module button 78 with his mouse cursor and clicking on it, the present display

and place in the training system will be marked so that the user can easily return to this display or point in the training software at a later time. This display is shown in Figure 16. This Bookmark function allows the user to jump around within the training software and to mark a point for the start point for the training application at a later date.

If the operator selects the Audio Functional Module button 89, the audio associated with the training software is toggled either on or off, depending on its present state.

If the operator selects the Back Functional Module button 77 with his cursor, the training software pages backwards.

This multi-media training system has many advantages. It serves as a quick reference guide and provides insight into the tooling process by use of simulation. It allows the user to walk through and practice the tooling operation for a particular part and gain expert advice on what common errors should be avoided. Additionally, the training system serves as a self testing device which allows the user to test their knowledge throughout the training evolution. A profile or history of each operator can be reviewed by an instructor or supervisor to aid in the training process. Alternately, the instructor or supervisor can administer a test to an operator from a remote site in real time by selecting or providing the test questions provided to the operator. An advantage of this system is that it provides direct and immediate sensory feedback to the operator for positive and negative feedback during the learning process. This training system enhances and improves the effectiveness of the learning experience by allowing the user the ability to access different instructional media. Through the integrated use of graphics, audio, video, computer animation, text,

hypertext and self-test this training system is much more effective than previous training methods and tools.

The memory 7 stores information defining the machine tool 11 including data defining various geometrical aspects (such as, for example, drill bit sizes or tool sizes, tool or drill bit motion limits, drill bit offset values, workpiece jig position range), and it stores templates representing ideal machine operations, such as would be expected to be performed by an expert machine operator, including for example, drill bit spin rate (RPM), drill bit velocity (e.g., toward the workpiece) and so forth. The training software 8 can interpret such information stored in the memory 7 to give meaning to a movement by the trainee 4 of the input device 12 (which may be a trackball, for example) as corresponding to a computer-controlled repositioning of the drill bit or a computer-commanded change in the drill bit velocity, for example. The training software 8 further interprets such information from the input device 12 in light of the machine-defining information in the memory 7 and in view of a history of machine movements thus commanded by the trainee 4 to determine the present state or position of each element (e.g., the drill bit and the workpiece) of the machine tool 11 and furthermore infer from such a history the nature of the operation being performed by the trainee 4. Furthermore, the training software 8 infers the parameters of such an operation and compares them with the templates of the ideal operations stored in the memory 7 to determine how well the trainee is doing and to determine what kinds of errors he may be committing. (Such errors may include, for example, the trainee selecting such a high velocity of a drill bit through a workpiece that the drill bit or workpiece would be overheated in a real machine operation.) The training software 8 further considers all of the foregoing information to generate feedback to the trainee, such as a simulated image of the machine and workpiece

illustrating in video the movements commanded by the trainee, and generating any error messages to the trainee or other helpful information of the type referred to previously in this specification. The geometric and other data stored in the memory 7 defining the machine tool 11 may be of the type required by the interface software 14 to perform actual or real computer controlled operation of the machine tool 11 (as distinguished from training simulations performed with simulated video graphics by the training software 8). Thus, the geometric and other data stored in the memory 7 for defining the machine tool 11 is a shared resource, as it is used by both the interface software 14 and the training software 8 to provide meaning to commands entered by the user (or trainee) in the form of commanded changes in the movements or operation of the machine tool 11. Both the interface software 14 and the training software 8 interpret the geometric data and machine-tool-defining data stored in the memory 7 to convert inputs from the user (via his input device 12) into commanded changes in the configuration, operation or movements of various elements of the machine tool. In the case of the training software 8, such changes are not forwarded to the machine tool 11 itself, but rather are forwarded to simulation modules of the training software which generate simulated images of the machine tool operation so as to incorporate such changes into the simulated images displayed during a training session. Furthermore, such changes are forwarded to other portions of the training software which compare the commanded machine tool movements and operation to the templates stored in the memory 7 for representing ideal or expert machine tool operations and movements. The memory may store a library of such information, data and templates for various machine tool configurations and operations (e.g., cutting, milling, lathe and so forth) so that the entire system is versatile adapts to various applications.

While the invention has been described by specific reference to preferred embodiments, it is understood that variations thereof may be made without departing from the true spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A computer implemented process for training an operator, comprising the steps of:

(a) providing an interactive computer environment with training software operating thereon, said training software having access to and exchanging data with a computer memory and having a graphical user interface for interfacing said operator with said computer environment;

(b) displaying a menu of said graphical user interface with training modules, each training module having preprogrammed sensory media associated with actual trainable machine tooling events of an external environment outside said computer environment;

(c) interactively training said operator with said preprogrammed sensory media of each of said training module of said computer environment so that said operator is taught to perform specific tasks and operations associated with a machine tool in said external environment outside said computer environment.

2. The method of Claim 1, wherein said step (b) comprises:

(b1) displaying a main menu of said graphical user interface for allowing the operator to select one of a plurality of training categories, each training category having a submenu and being associated with an actual event category of an external environment outside said computer environment;

(b2) displaying a first submenu associated with said selected category of said main menu for allowing the operator to select one of a plurality of training operations, each training operation having secondary submenus and being associated with

an actual event operation of an external environment outside said computer environment; and

(b3) displaying a secondary submenu associated with said selected training operation of said submenu for allowing the operator to select one of a plurality of training modules, each training module having sensory media and being associated with actual event tasks of an external environment outside said computer environment;

wherein one of said displaying steps is accompanied by at least one of video, audio, graphics, preprogrammed animation and text for immediate sensory feedback.

3. The method of Claim 2 wherein step (b1) comprises displaying a text window for providing textual information and operator selectable hypertext and a graphical window for providing graphical information and operator selectable hypergraphics associated with actual events of an external environment outside said computer environment.

4. The method of Claim 1 further comprising linking said computer memory of said interactive computer environment with a remote station having an instructor for monitoring and supervising said operator in real time, wherein said remote station shares access to and exchanges data with said computer memory.

5. The method of Claim 1 further comprising providing interface software operating on said interactive computer environment for controlling said machine tool in said external environment outside said computer environment, wherein said interface software shares access to and exchange of data with said computer memory.

6. The method of Claim 2 wherein step (b2) further comprises providing an operator selectable simulation training module for viewing a preprogrammed simulation of training operations.

7. The method of Claim 6 wherein the step (b2) further comprises displaying a preprogrammed animated sequence of steps replicating actual steps of said training operation in a graphical window.

8. The method of Claim 7 wherein step (b2) further comprises displaying accompanying text and hypertext in a text window for providing explanatory of text and hypertext said training operations.

9. The method of Claim 2 wherein step (b2) further comprises providing an operator selectable example training operation module for viewing a preprogrammed example of training operations.

10. The method of Claim 9 wherein the step (b2) further comprises displaying a preprogrammed animated sequence of steps replicating actual steps of said training operation in a graphical window.

11. The method of Claim 9 wherein step (b2) further comprises displaying accompanying text and hypertext in a text window for providing explanatory of text and hypertext said training operations.

12. The method of Claim 6 wherein the step (b2) further comprises displaying a preprogrammed video sequence of steps replicating actual steps of said training operation in a graphical window.

13. The method of Claim 6 wherein step (b2) comprises providing an operator selectable practice training module for allowing the operator provide input and to perform preprogrammed practice simulation steps of training operations.

14. The method of claim 13 wherein the step (b2) further comprises displaying a preprogrammed animated sequence of steps replicating actual steps of said training operation in a graphical window.

15. The method of Claim 13 wherein step (b2) further comprises displaying accompanying text and hypertext in a text window for providing explanatory of text and hypertext said training operations.

16. The method of Claim 13 wherein the step (b2) further comprises displaying a preprogrammed video sequence of steps replicating actual steps of said training operation in a graphical window.

17. The method of Claim 15 wherein the step (b2) further comprises displaying the accompanying text and prompting the operator to respond to preprogrammed questions and instructions on performing said training operations.

18. The method of Claim 13 wherein the step (b2) further comprises displaying error modules prompted by preprogrammed events occurring associated with operator error input.

19. The method of Claim 18 wherein the step (b2) further comprises the steps of counting and recording in said computer memory input by said operator and input errors received by said operator during training for later review and generating a history profile of said operator.

20. The method of Claim 2 wherein the step (b2) further comprises providing an operator selectable walk through training module for allowing the operator provide input for performing a preprogrammed walk through simulation of training operations.

21. The method of Claim 20 wherein the step (b2) further comprises displaying a preprogrammed animated sequence of steps replicating actual steps of said training operation in a graphical window.

22. The method of Claim 20 wherein step (b2) further comprises displaying accompanying text and hypertext in a text window for providing explanatory of text and hypertext said training operations.

23. The method of Claim 20 wherein the step (b2) further comprises displaying a preprogrammed video sequence of steps replicating actual steps of said training operation in a graphical window.

24. The method of Claim 20 wherein the step (b2) further comprises displaying the accompanying text and prompting the operator to respond to preprogrammed questions and instructions on performing said training operations.

25. The method of Claim 2 wherein the step (b2) further comprises providing an operator selectable expert training module for providing input and in response for viewing a preprogrammed interactive session of frequently asked questions with text and hypertext to additional information of training operations.

26. The method of Claim 2 wherein the step (b2) further comprises providing an operator selectable self-test training module for allowing the operator to input data and in response to view a preprogrammed interactive testing session of training operations.

27. The method of Claim 26 wherein the step (b2) further comprises displaying a preprogrammed animated sequence of steps replicating actual steps of said training operation in a graphical window.

28. The method of Claim 26 wherein step (b2) further comprises displaying accompanying text and hypertext in a text window for providing explanatory of text and hypertext said training operations.

29. The method of Claim 26 wherein the step (b2) further comprises displaying a preprogrammed video sequence of steps replicating actual steps of said training operation in a graphical window.

30. The method of Claim 26 wherein the step (b2) further comprises displaying the accompanying text and prompting the operator to respond to preprogrammed questions and instructions on performing said training operations.

31. The method of Claim 26 wherein the step (b2) further comprises the steps of counting and recording in said computer memory input by said operator during

training of said self-test module for later review and generating a history profile of said operator.

32. The method of Claim 31 wherein the step (b2) further comprises displaying error modules prompted by preprogrammed events occurring associated with operator error input.

33. A training system for training an operator, comprising:

an interactive computer environment with training software operating thereon, said training software having access to and exchanging data with a computer memory and having a graphical user interface for interfacing said operator with said computer environment; and

wherein said graphical user interface includes a menu with training modules, each training module having preprogrammed sensory media associated with actual trainable machine tooling events of an external environment outside said computer environment;

wherein said operator is interactively trained with said preprogrammed sensory media of each of said training module of said computer environment so that said operator is taught to perform specific tasks and operations associated with a machine tool in said external environment outside said computer environment.

34. The system of Claim 33, wherein said graphical user interface further comprises:

a main menu for allowing the operator to select one of a plurality of training categories, each training category having a submenu and being associated with an actual event category of an external environment outside said computer environment;

a first submenu associated with said selected category of said main menu for allowing the operator

to select one of a plurality of training operations, each training operation having secondary submenus and being associated with an actual event operation of an external environment outside said computer environment; and

a secondary submenu associated with said selected training operation of said submenu for allowing the operator to select one of a plurality of training modules, each training module having sensory media and being associated with actual single event tasks of an external environment outside said computer environment;

wherein one of said menus are accompanied by at least one of video, audio, graphics, preprogrammed animation and text for immediate sensory feedback.

35. The system of Claim 33 further comprising a remote station linked with said computer memory of said interactive computer environment, said remote station having an instructor for monitoring and supervising said operator in real time, wherein said remote station shares access to and exchanges data with said computer memory.

36. The system of Claim 33 further comprising interface software operating on said interactive computer environment for controlling said machine tool in said external environment outside said computer environment, wherein said interface software shares access to and exchange of data with said computer memory.

37. The system of Claim 33 wherein said graphical user interface further comprises an operator selectable practice training module for allowing the operator provide input and to perform preprogrammed practice simulation steps of training operations.

38. The system of Claim 37 further comprising error modules prompted by preprogrammed events occurring associated with operator error input.

39. The system of Claim 38 further comprising a device for counting and recording in said computer memory

input by said operator and input errors received by said operator during training for later review and generating a history profile of said operator.

40. A computer-readable medium for causing an interactive computer to function as a training system for training an operator, comprising:

a computer-readable storage medium;

a computer program stored on said medium;

said computer program having an interface for accessing in real-time a database containing preprogrammed sensory media associated with actual trainable machine tooling events of an external environment outside said computer;

said computer program having a graphical user interface module for interfacing a user with said computer program and said sensory media, wherein said graphical user interface module includes a menu with training modules, each training module associated with said preprogrammed sensory media;

wherein said operator is interactively trained with said preprogrammed sensory media of each of said training module or said computer so that said operator is taught to perform specific tasks and operations associated with a machine tool in said external environment outside said computer.

41. The system of Claim 40, wherein said graphical user interface further comprises:

a main menu for allowing the operator to select one of a plurality of training categories, each training category having a submenu and being associated with an actual event category of an external environment outside said computer;

a first submenu associated with said selected category of said main menu for allowing the operator to select one of a plurality of training operations, each training operation having secondary submenus and being associated with an actual event operation

of an external environment outside said computer; and

a secondary submenu associated with said selected training operation of said submenu for allowing the operator to select one of a plurality of training modules, each training module having sensory media and being associated with actual single event tasks of an external environment outside said computer;

wherein one of said menus are accompanied by at least one of video, audio, graphics, preprogrammed animation and text for immediate sensory feedback.

42. The system of Claim 40 further comprising a remote station linked with said computer medium of said interactive computer, said remote station having an instructor for monitoring and supervising said operator in real time, wherein said remote station shares access to and exchanges data with said computer medium.

43. The system of Claim 40 further comprising interface software operating on said interactive computer for controlling said machine tool in said external environment outside said computer, wherein said interface software shares access to and exchange of data with said computer medium.

44. The system of Claim 40 wherein said graphical user interface further comprises an operator selectable practice training module for allowing the operator provide input and to perform preprogrammed practice simulation steps of training operations.

45. The system of Claim 44 further comprising error modules prompted by preprogrammed events occurring associated with operator error input.

46. The system of Claim 45 further comprising a device for counting and recording in said computer medium input by said operator and input errors received by said operator during training for later review and generating a history profile of said operator.

47. A computer implemented process for training an operator, comprising the steps of:

storing tool data representing a machine tool and the possible movements of operational elements thereof and templates representing ideal machine tool operations;

interpreting (a) inputs from a trainee in an interactive computer environment and (b) said tool data, so as to deduce simulated changes in operation of said machine tool corresponding to said inputs from said trainee;

interpreting said simulated changes with reference to said templates so as to generate therefrom training feedback information and displaying said training feedback information to said trainee in said interactive computer environment.

48. The method of Claim 47 wherein said analyzing comprises deducing error trends in said simulated changes commanded by said trainee by comparison thereof with said templates.

49. The method of Claim 48 wherein said generating feedback information comprises generating messages conveying information characterizing said error trends for said trainee.

50. The method of Claim 49 wherein the generating of said feedback information comprises generating a three-dimensional motion image of said machine tool operation representing said simulated changes for display to said trainee.

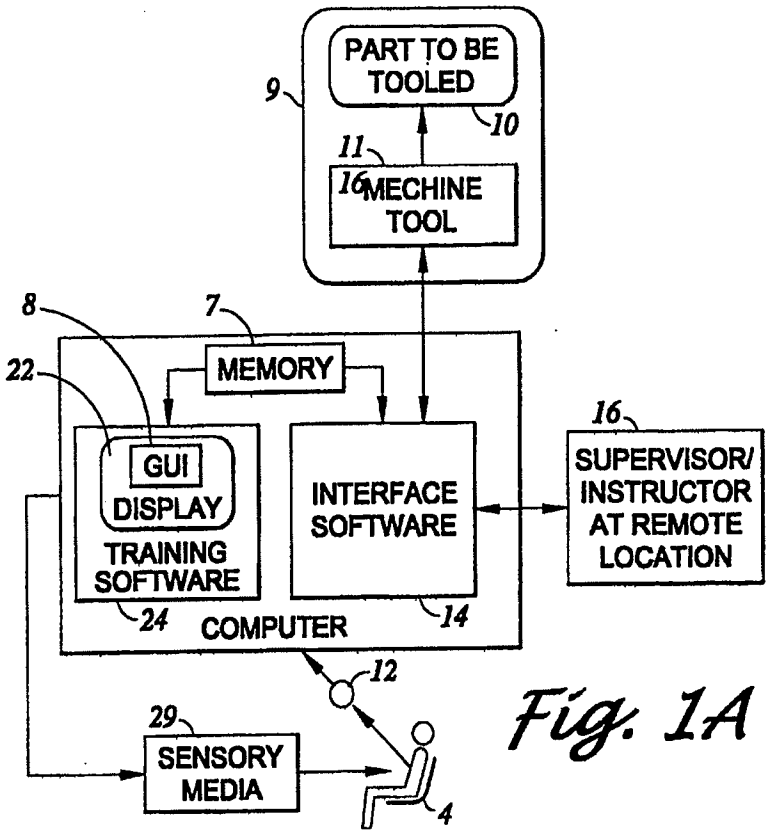
PART TO BE TOOLED
9
10
11
16
MECHINE TOOL
8
7
MEMORY
22
GUI
DISPLAY
TRAINING SOFTWARE
24
INTERFACE SOFTWARE
14
COMPUTER
16
SUPERVISOR/ INSTRUCTOR AT REMOTE LOCATION
12
29
SENSORY MEDIA
4

Fig. 1A

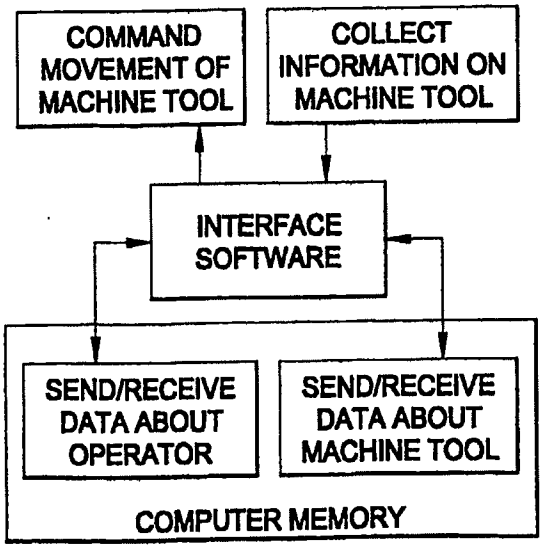
COMMAND MOVEMENT OF MACHINE TOOL
COLLECT INFORMATION ON MACHINE TOOL
INTERFACE SOFTWARE
SEND/RECEIVE DATA ABOUT OPERATOR
SEND/RECEIVE DATA ABOUT MACHINE TOOL
COMPUTER MEMORY

Fig. 1B

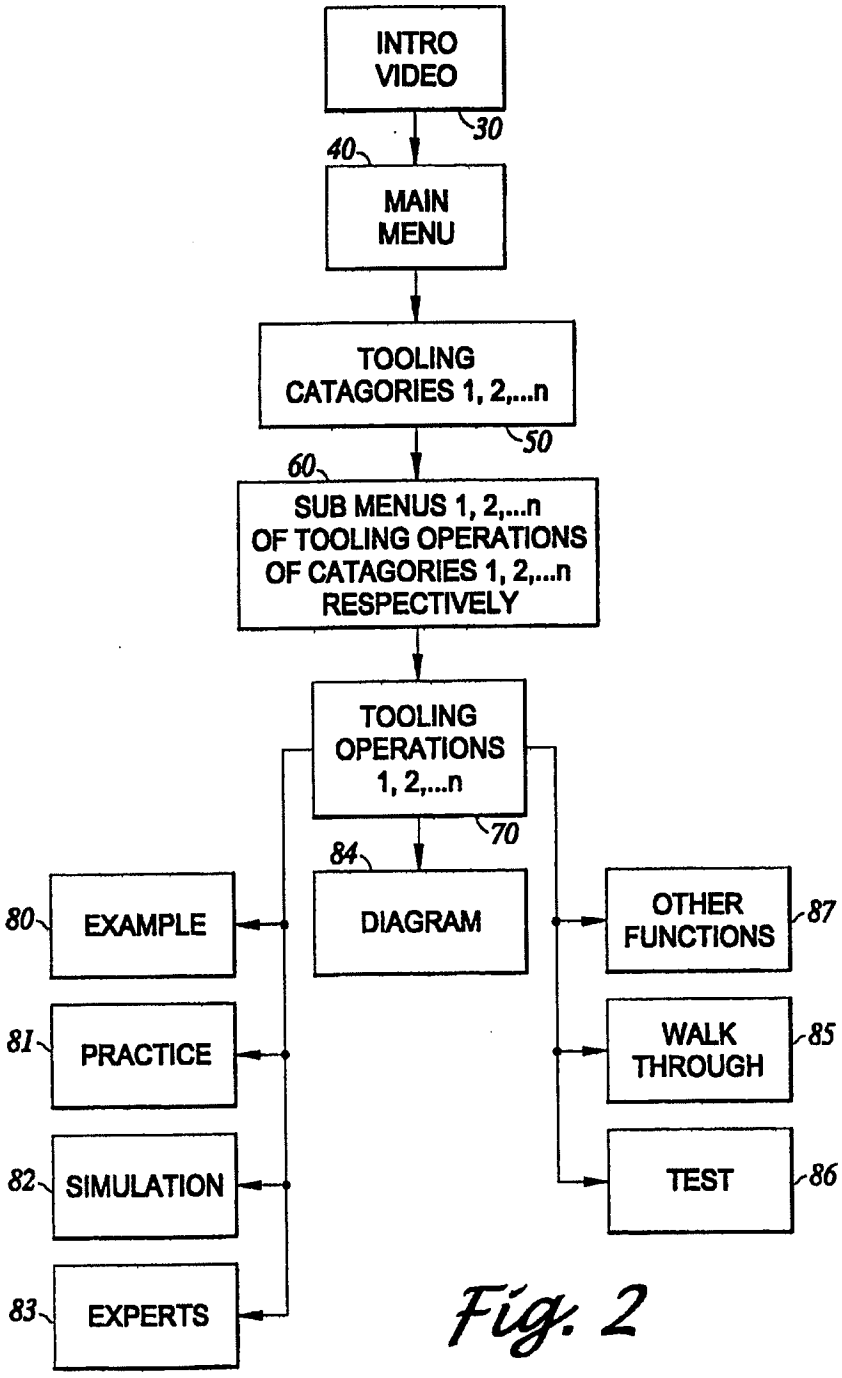
INTRO VIDEO
30
40
MAIN MENU
TOOLING CATAGORIES 1, 2,...n
50
60
SUB MENUS 1, 2,...n OF TOOLING OPERATIONS OF CATAGORIES 1, 2,...n RESPECTIVELY
TOOLING OPERATIONS 1, 2,...n
70
84
80
EXAMPLE
DIAGRAM
OTHER FUNCTIONS
87
81
PRACTICE
WALK THROUGH
85
82
SIMULATION
TEST
86
83
EXPERTS

Fig. 2

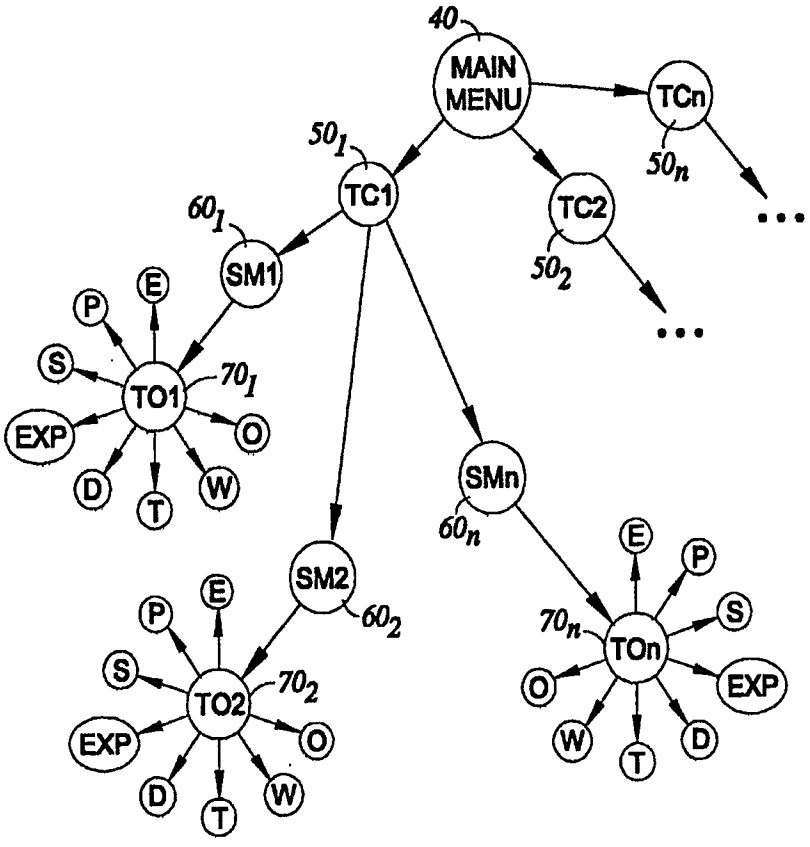
40
MAIN MENU
TCn
50n
501
TC1
TC2
502
601
SM1
P
E
S
TO1
701
EXP
O
D
T
W
SMn
60n
SM2
602
P
E
S
TO2
702
EXP
O
D
T
W
E
P
S
701
TOn
O
EXP
W
T
D

Fig. 3

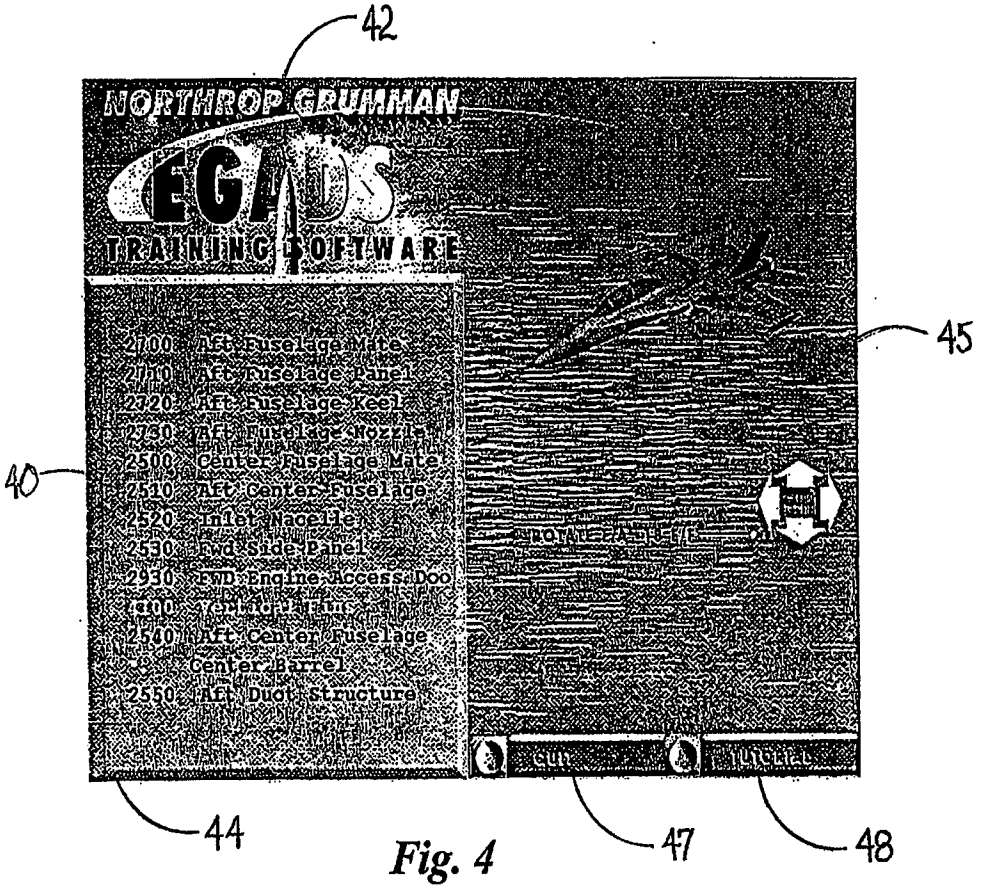
42
NORTHROP GRUMMAN
EGADS
TRAINING SOFTWARE
2700 Aft Fuselage Mate
2710 Aft Fuselage Panel
2720 Aft Fuselage Keel
2730 Aft Fuselage Nozzle
2500 Center Fuselage Mate
2510 Aft Center Fuselage
2520 Inlet Nacelle
2530 Fwd Side Panel
2930 FWD Engine Access Doo
2540 Aft Center Fuselage
Center Barrel
2550 Aft Duct Structure
40
45
44
47
48

Fig. 4

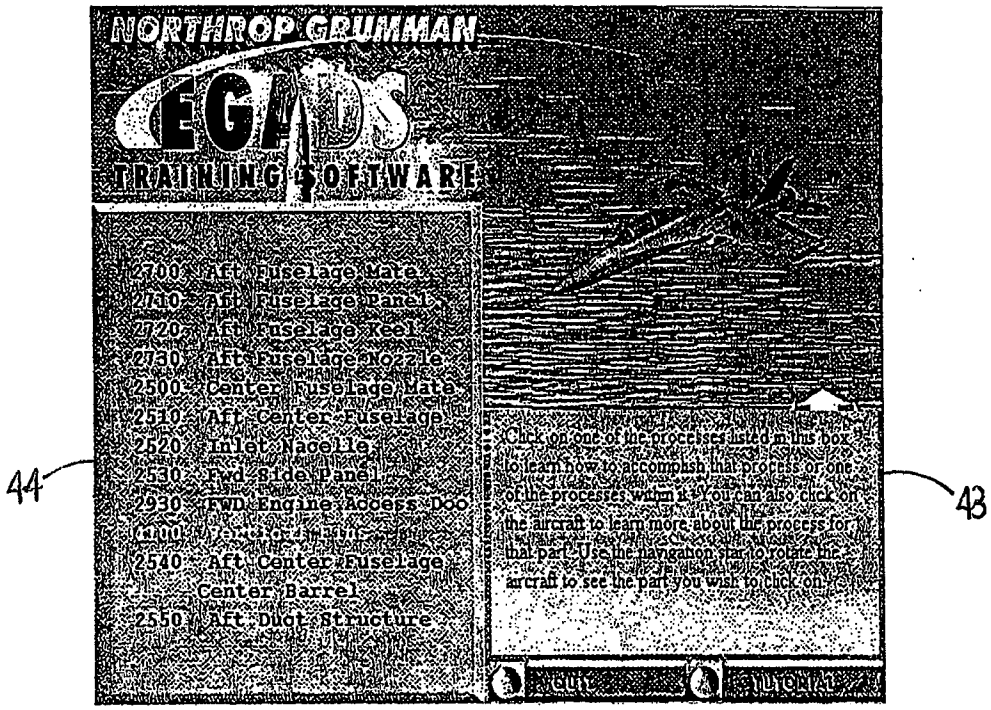
NORTHROP GRUMMAN
EGADS
TRAINING SOFTWARE
2700 Aft Fuselage Mate
2710 Aft Fuselage Panel
2720 Aft Fuselage Keel
2730 Aft Fuselage Nozzle
2500 Center Fuselage Mate
2510 Aft Center Fuselage
2520 Inlet Nacelle
2530 Fwd Side Panel
2930 FWD Engine Access Doo
2540 Aft Center Fuselage
Center Barrel
2550 Aft Duct Structure
Click on one of the processes listed in this box
to learn how to accomplish that process or one
of the processes within it. You can also click on
the aircraft to learn more about the process for
that part. Use the navigation tools to rotate the
aircraft to see the part you wish to click on.
Quit
TUTORIAL
44
43

Fig. 5

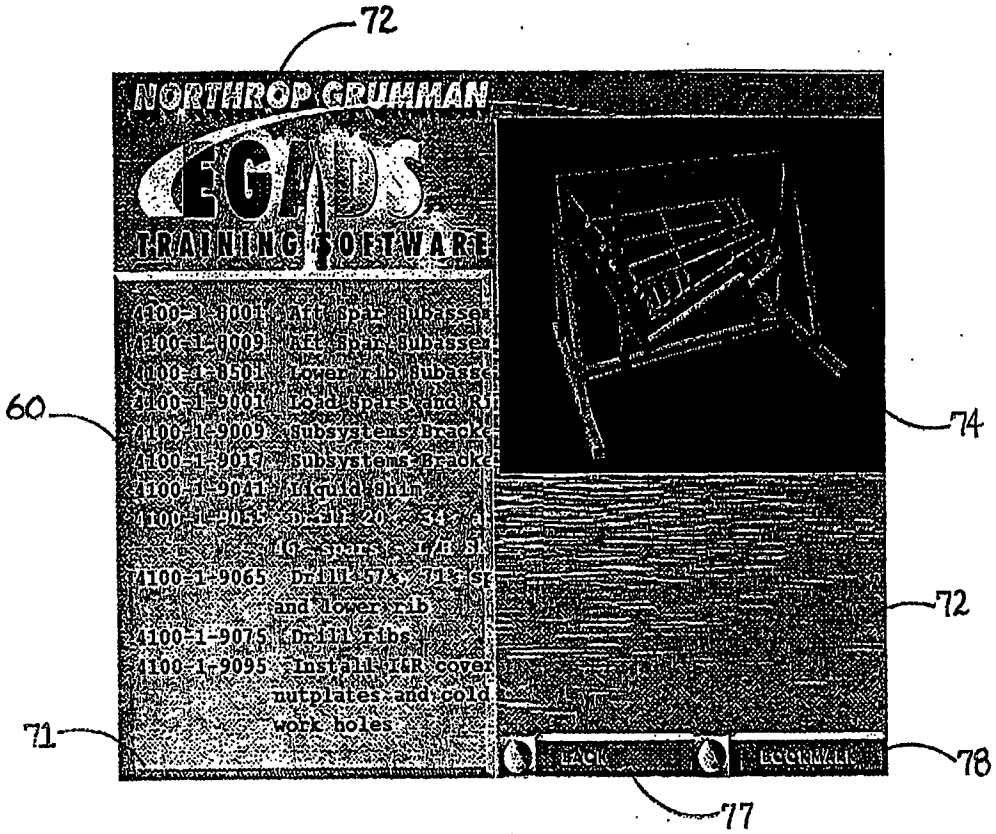
72
NORTHROP GRUMMAN
EGADS
TRAINING SOFTWARE
4100-1-9001 Aft Spar Subasse
4100-1-9009 Aft Spar Subasse
4100-1-9501 Lower rib Subasse
4100-1-9001 Load Spars and Ri
4100-1-9009 Subsystems Bracke
4100-1-9019 Subsystems Bracke
4100-1-9041 Liquid Shim
4100-1-9055 D-ds 20, 34, 4
LG Spars, A/R 3
4100-1-9065 Drill 4.57&, 71 Sp
and lower rib
4100-1-9075 Drill ribs
4100-1-9095 Install I&R cover
nutplates and cold
work holes
60
71
74
72
BACK
78
77

Fig. 6

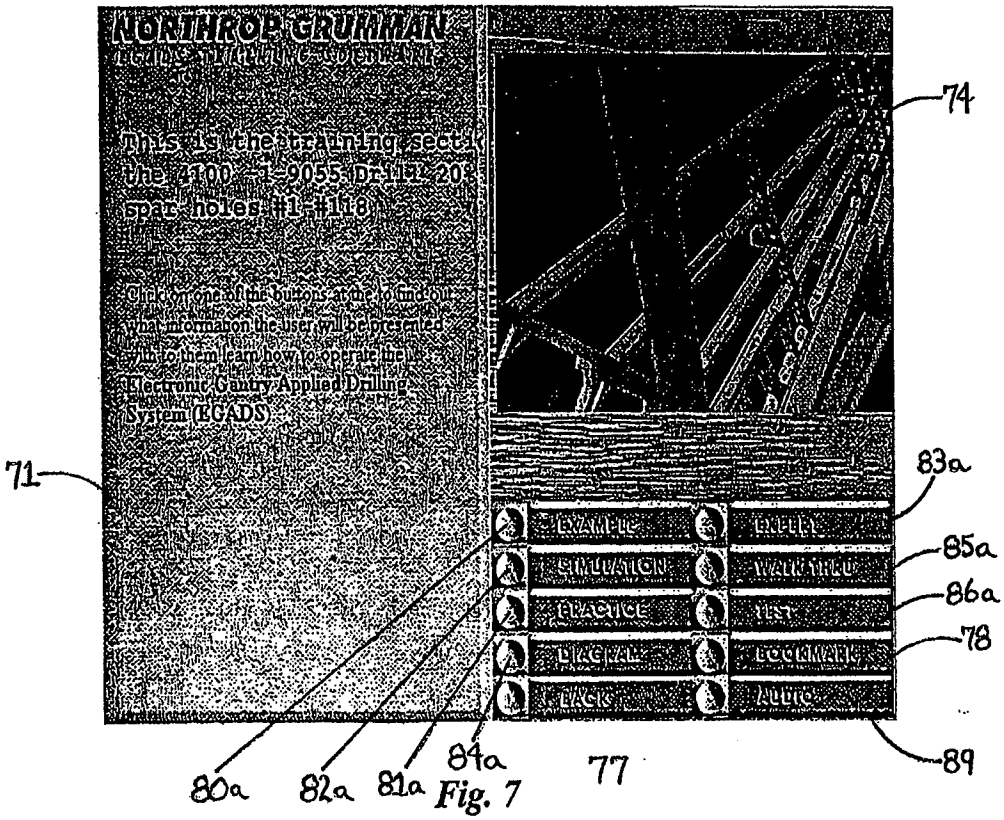
NORTHROP GRUMMAN
This is the training sect
the 4100 -1-9055 Drill 20
spac holes #1-#118
Click on one of the buttons at the to find out
what information the user will be presented
with to them learn how to operate the
Electronic Gantry Applied Drilling
System (EGADS)
EXAMPLE
SIMULATION
PRACTICE
DIAGRAM
BACK
TEST
BOOKMARK
ABORT
71
74
83a
85a
86a
78
89
80a
82a
81a
84a
77

Fig. 7

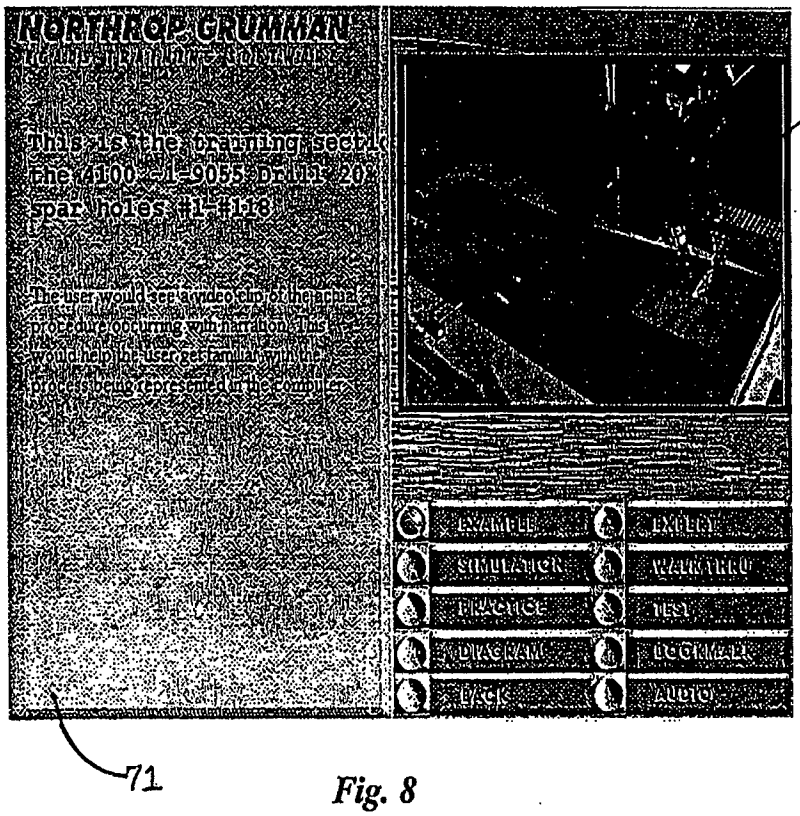
NORTHROP GRUMMAN
This is the drilling sectio
The 4100-1-9055 Drill 20
Spar holes #1-#118
The user would see a video clip of the actual
procedure occurring with narration. This
would help the user get familiar with the
process being represented in the computer.
EXAMPLE
EXERCISE
SIMULATOR
WALKTHRU
PRACTICE
TEST
DIAGRAM
LOGFORMAT
BACK
AUDIO
74
71

Fig. 8

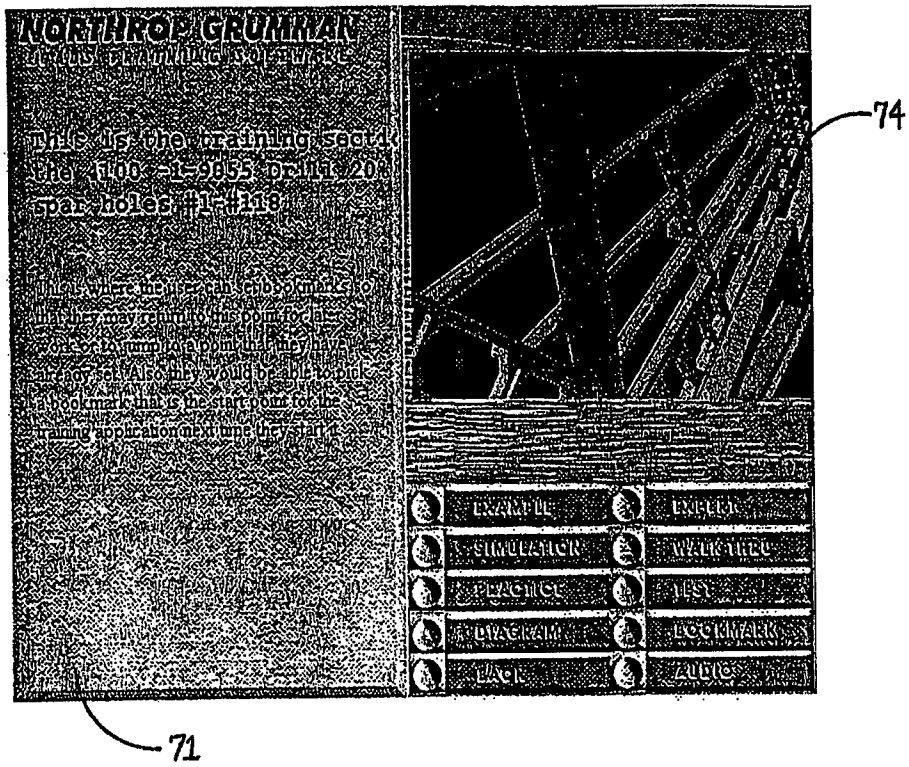
NORTHROP GRUMMAN
This is the training sect
the A100-1-9855 Drill 20
spar holes #1-#118
EXAMPLE
SIMULATOR
PRACTICE
DIAGRAM
EXIT
BOOKMARK
ABOUT
74
71

Fig. 9

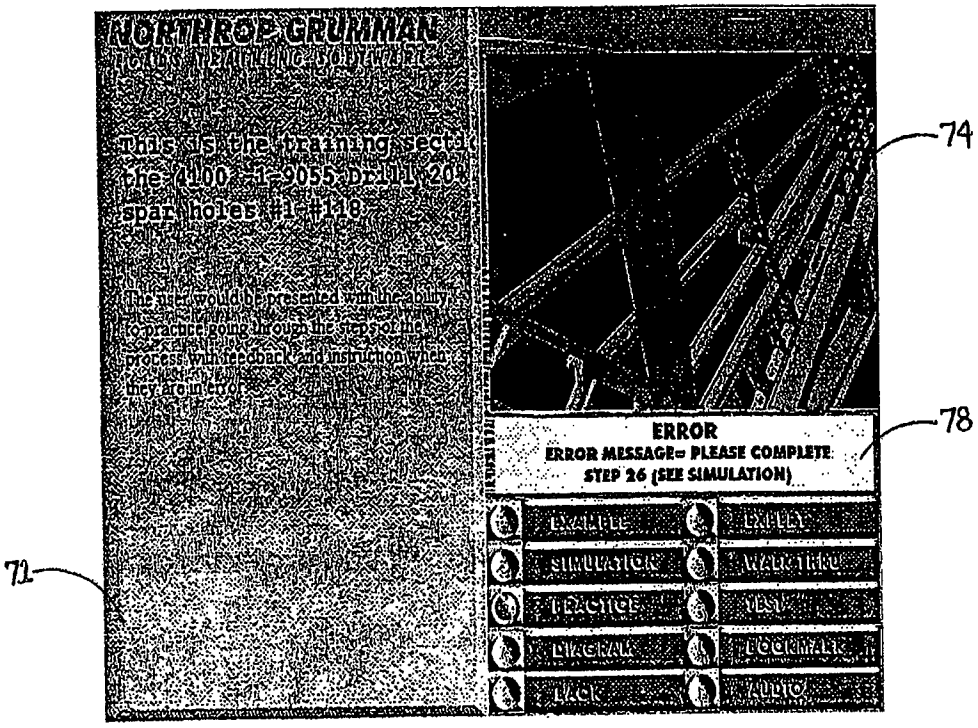
NORTHROP GRUMMAN
This is the training sect
the 4100 -1-9055 Dr 111 20
spar holes #1-#118
ERROR
ERROR MESSAGE= PLEASE COMPLETE
STEP 26 (SEE SIMULATION)
EXAMPLE
SIMULATION
PRACTICE
DIAGNAL
BACK
74
78
71

Fig. 10

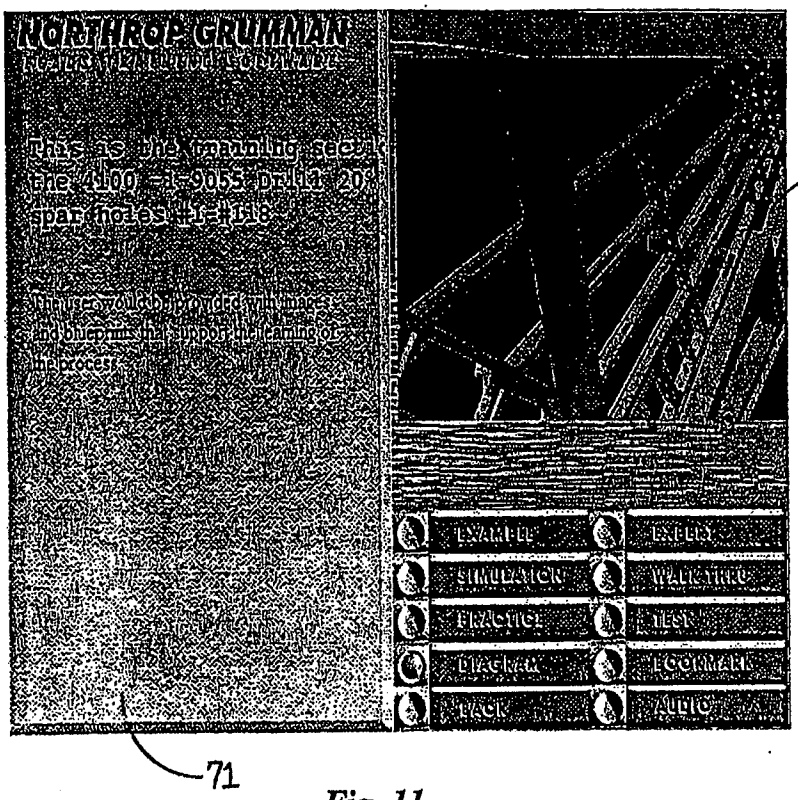

Fig. 11

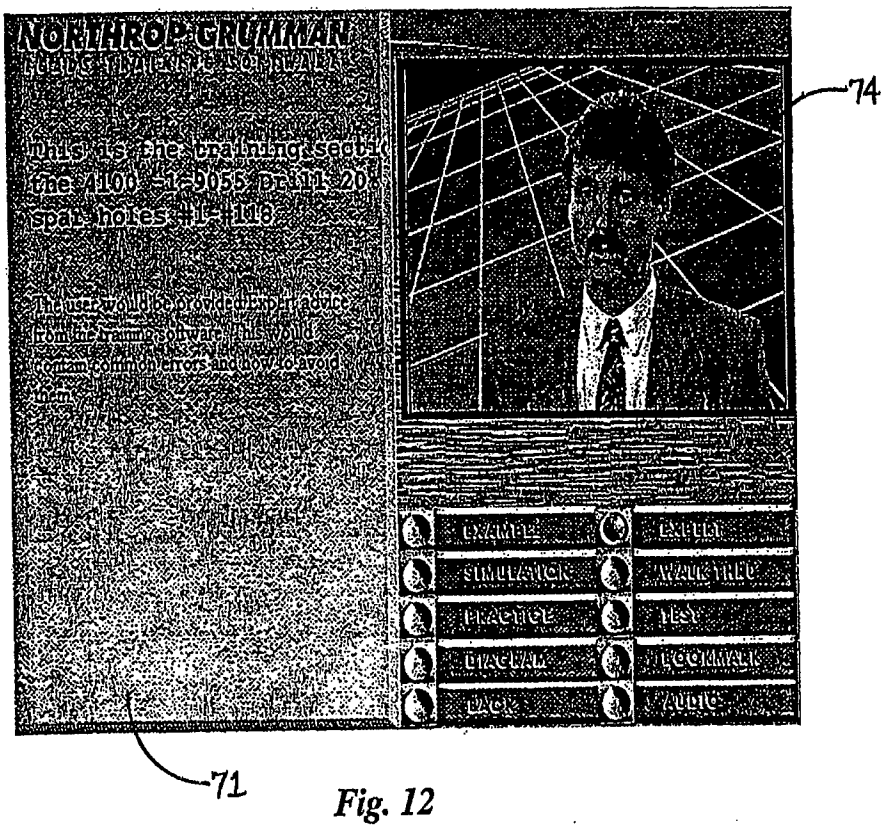
NORTHROP GRUMMAN
EXAMPLE
SIMULATION
PRACTICE
DIAGRAM
BACK
EXPLAIN
WALKTHRU
TEST
TECHNICAL
AUDIO
74
71

Fig. 12

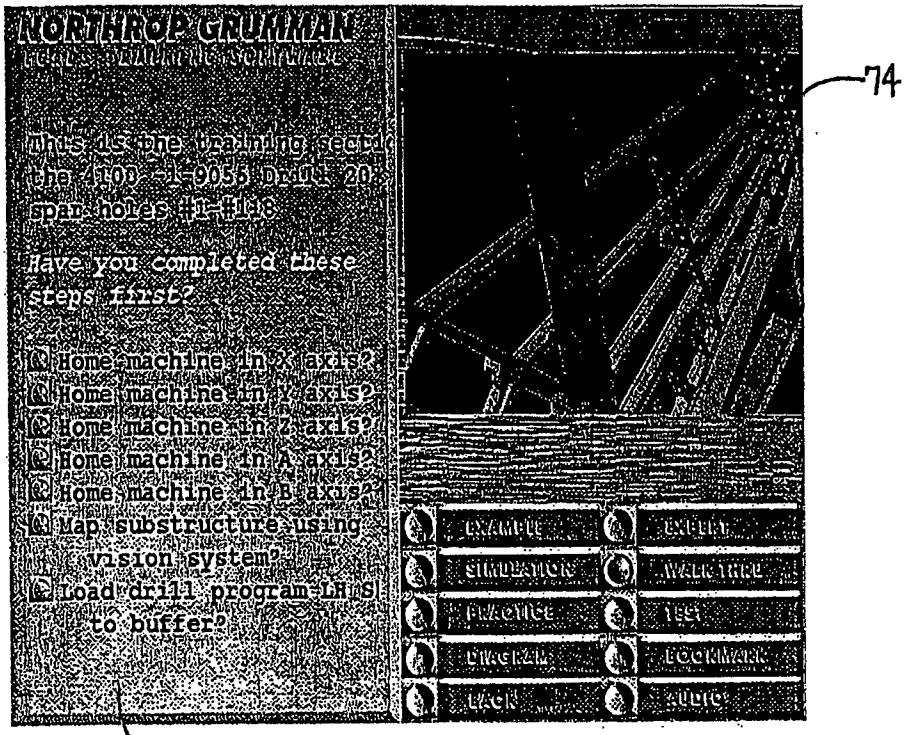
NORTHROP GRUMMAN
What is the reaming speed for the 4-40 -1-9056 Drill 20 span holes #1-#18
Have you completed these steps first?
Home machine in X axis?
Home machine in Y axis?
Home machine in Z axis?
Home machine in A axis?
Home machine in B axis?
Map substructure using vision system?
Load drill program LH S to buffer?
EXAMPLE
SIMULATION
PRACTICE
DIAGRAM
EXIT
WALK-THRU
TEST
BOOKMARK
74
71

Fig. 13

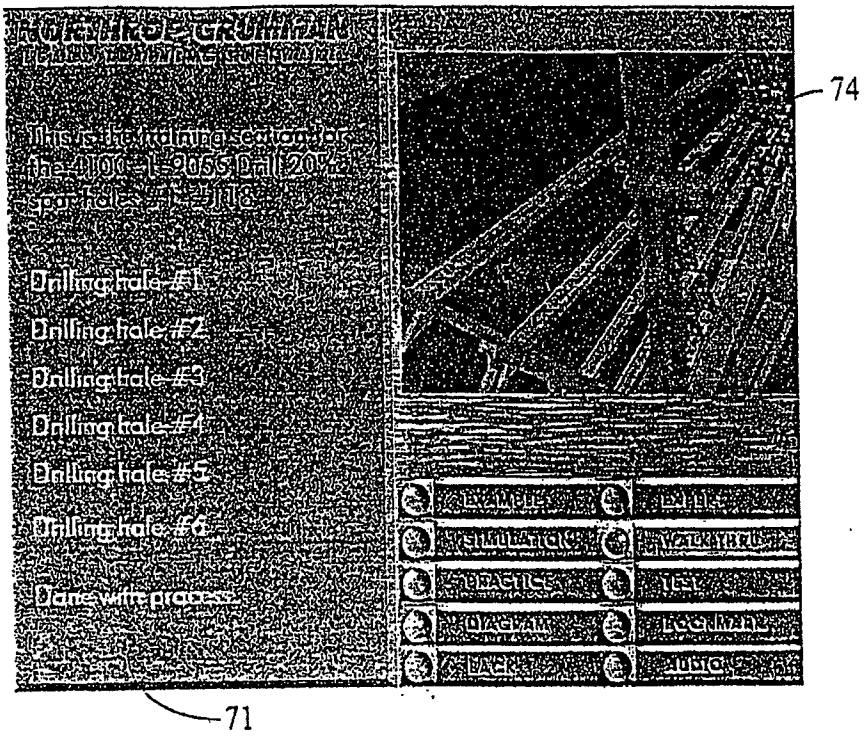

FIG. 14

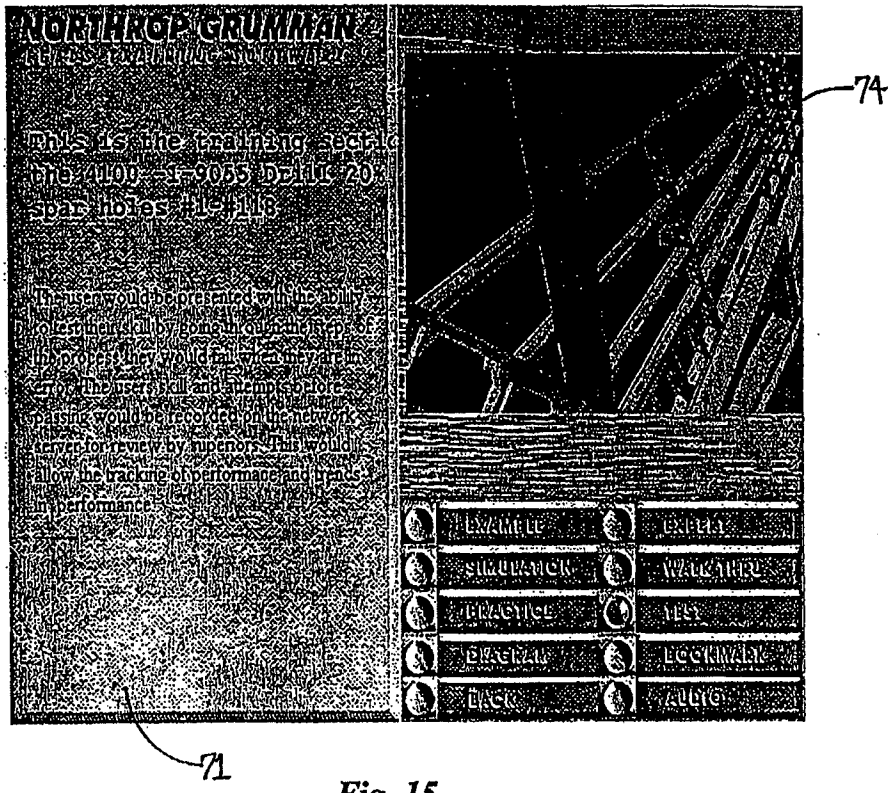
NORTHROP GRUMMAN
EXAMINE
EXPLAIN
SIMULATION
WALKTHRU
PRACTICE
TEST
DIAGRAM
BOOKMARK
BACK
AUDIO
74
71

Fig. 15

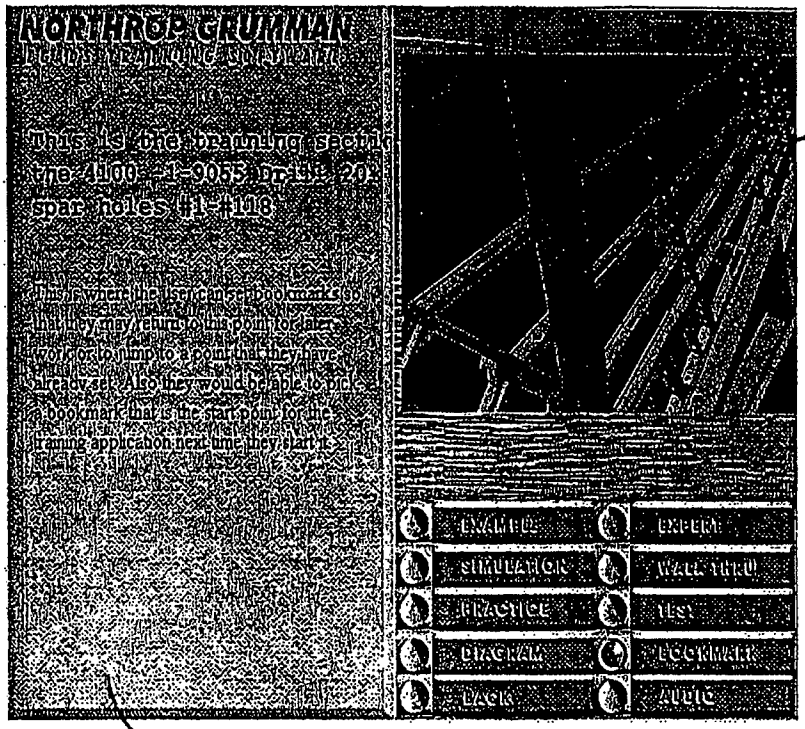
NORTHROP GRUMMAN
This is the training secti
the 4100 -1-9055 or the 20
spac holes #1-#118
EXAMINE
EXPERT
SIMULATION
WALK THRU
PRACTICE
TEST
DIAGRAM
BOOKMARK
BACK
AUDIO
74
71

Fig. 16